

Flight Experiments using Mega-Float Airport Model

Tetsuo KIKUTAKE, Kazushige DAIKI
Technological Research Association of Mega-Float
3-15-3 shiba, Minato-ku, Tokyo 105-0014, JAPAN

1. Introduction

Mega-Float, which is a kind of steel made Very Large Floating Structure (VLFS), has a great potential as an artificial foundation for offshore airports such as large metropolis airport or special purpose airport tentatively used. The realization of Mega-Float airport is strongly expected, since Mega-Float provides smaller environment loads and is less susceptible to earthquake, compared with the conventional reclamation. Though Mega-Float airport has various advantages mentioned above, it has some characteristics different from reclaimed airport, and effects of those characteristics such as motion caused by wave must be analyzed whether it is harmless for airport use.

For this purpose, Technological Research Association of Mega-Float (TRAM, established in April 1995) has been conducted research programs. The principal objective of the research program is to carry out experiments using Mega-Float model on sea and to confirm the reliability of technologies used for the design, construction and function assessment of Mega-Float, with the data measured.

In this report, outline of research programs on Mega-Float airport and a part of the results are described.

2. Outline of Research Programs for Realization of Mega-Float Airport

For realization of Mega-Float airport, effects of Mega-Float characteristics on airport facilities and their functions must be analyzed, then the integrity of Mega-Float airport should be recognized by its users such as airport authorities, pilots, airline companies etc. Fig. 1 shows the relation among Mega-Float characteristics, airport facilities and their functions. Through the research program Phase I, started in April 1995 and ended in March 1998, various analysis programs in Fig. 1 have been developed and the assessment on the operation of Mega-Float airport has become possible using these analysis programs. Then through the simulation experiment using flight-simulator, landing of B747-400 on Mega-Float airport is confirmed to be possible by active airline pilots (1).

Since the size of Mega-Float model (300m long) used for Phase I program was too short for airplane landing, which was considered to be essential to confirm

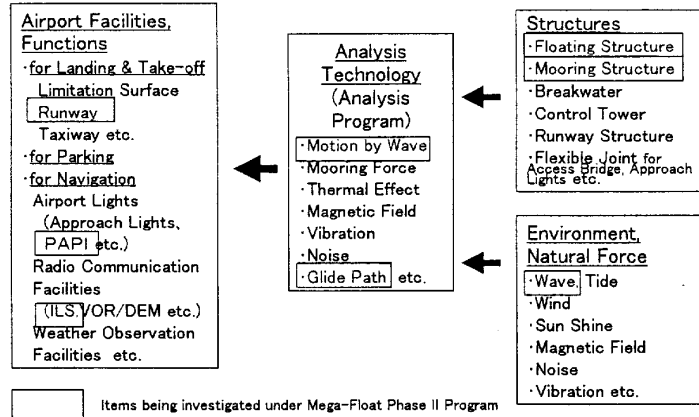


Fig. 1 Relations among Mega-Float Characteristics, Airport Facilities and Functions

the reliability of Mega-Float airport, it was decided to start Phase II program using large model, which is enough long for airplane landing.

3. The Phase II Research Program and the tentative Results

The principal objective of Phase II program is to obtain the data, necessary for the confirmation of Mega-Float airport reliability, using the full scale model and actual plane under actual sea conditions. The Phase II program started in April 1998. Its schedule is indicated in Fig. 2.

Main Theme	F.Y.1998				F.Y.1999				F.Y.2000			
	1/4	2/4	3/4	4/4	1/4	2/4	3/4	4/4	1/4	2/4	3/4	4/4
M.F. Airport Landing Simulation	Preparation of Element Analysis				Refine of Programs				Simulation Test			
Verification Test on ILS, PAPI	Preparation of ILS, PAPI				Flight Check				Flight Check			
Airplane Landing Practice					Preparation for Landing				Landing Practice			
Flight under FANS	Technology Survey				Preparation				FANS/GEAS Flight			
Construction of M.F. Airport Model	Construction & Joining of M.F. Units				Pavement Construction							

Fig. 2 Schedule of Mega-Float Phase II Program

The schedule of Phase II program is classified to the three stages shown below.

Stage 1: Confirmation of the reliability of airport facilities such as Instrument Landing System (ILS) and Precision Approach Path Indicator (PAPI) with flight check.

Stage 2: Airplane landing practice under Visual Flight Rules (VFR) and Future Air Navigation System (FANS)/ Ground Base Augmentation System (GBAS).

Stage 3: Confirmation of the integrity of large Mega-Float airport operation using flight simulator, whose simulation programs are brushed up with the data obtained at stage 1 and 2.

3.1 Mega-Float Airport Model, Airport Facilities and Sensors

Mega-Float airport model (MF airport model hereafter), which is enough long for airplane landing, has been constructed at Yokosuka Bay. On the model, airport facilities such as ILS, which is composed of Glide Slope (GS) and Localizer (LLZ), and PAPI, which might be affected by the motion of Mega-Float, were installed. Fig. 3 shows a plan of the model and locations of the airport facilities. Photo. 1 shows PAPI installed. Since space of MF airport model is limited, 2 lights system PAPI (A-PAPI) is applied. Photo.2 shows GS system. Control room of MF airport model is also seen in the same Photo. Photo. 3 shows LLZ antenna, which is 1 frequency type and was transplanted from a local airport with 2000m runway.

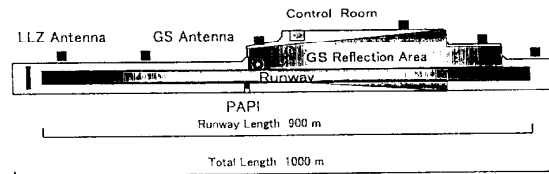


Fig. 3 Location of Airport Facilities on the Mega-Float Airport Model



Photo.1 PAPI installed on the Mega-Float Airport Model

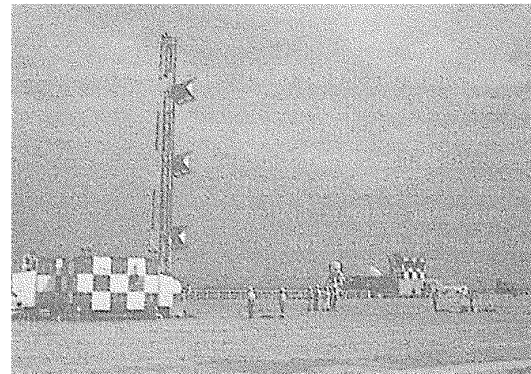


Photo.2 Glide Slope(GS) System and Control Room on the Mega-Float Airport Model



Photo.3 Localizer(LLZ) Antenna on the Mega-Float Airport Model

Various sensors are installed in the MF airport model to measure various properties such as motion and stress of the model, weather and sea conditions etc. Fig. 4 shows the locations of sensors(2). The data obtained through these sensors are automatically recorded and applied for analysis.

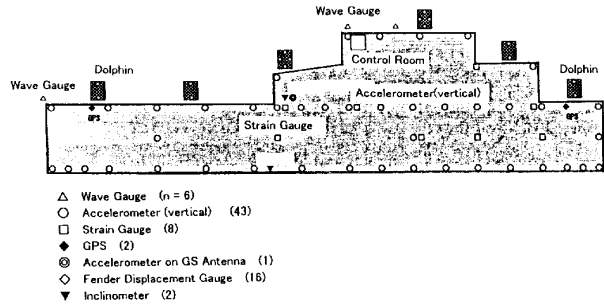


Fig. 4 Location of various Sensors in the Mega-Float Airport Model

3.2 Flight Check

First flight check was conducted during September 27 to October 18, 1999, for the adjustment first, then for the check of ILS and PAPI. The flight check was carried out by Japan Civil Aviation Bureau (JCAB) with flight checker YS-11. Fig. 5 shows the typical approach pattern to measure GS signal. Photo. 4 shows the flight checker YS-11 inspecting LLZ.

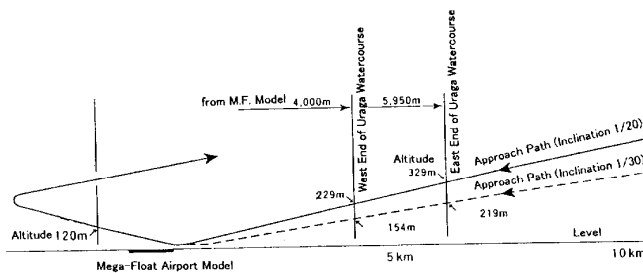


Fig. 5 Typical Approach Pattern of Flight Checker YS-11 for GS Inspection



Photo.4 Flight Checker YS-11 inspecting LLZ

The relations among ILS (especially GS) signal, PAPI signal and motion of MF airport model, which are observed during the flight check, are very important to confirm and brush up the analysis/simulation programs. Since the motion of the MF airport model was expected too small to observe for existing measuring system, optical motion measuring system was employed to measure very small motion/rotation of the model caused by waves. Photo. 5 shows the equipment for optical motion measuring system.

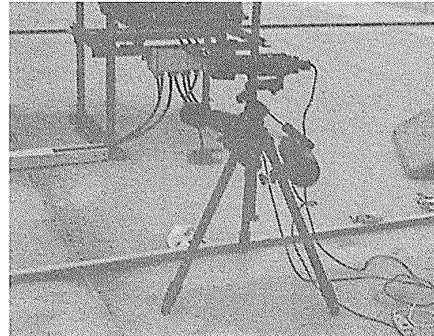


Photo.5 Equipment used for Optical Motion Measurement

3.2.1 Weather and Sea Conditions during the Flight Check

Weather and sea conditions are shown in Table 1. North wind is dominant and the wave caused by the wind

reached up to 0.64m effective wave height. According to the survey conducted in 1998 (2), 0.64m effective wave height covers over 85% reappearance probability in the site, where the MF airport model locates. Thus the flight check was carried out under relatively sever wave conditions in the site. Since flight check is conducted under VFR, which requires good weather conditions such as the visibility of over 5,000meters and the cloud ceiling of over 300meters, a flight check under more sever wave condition seems difficult.

Table 1 Weather & Sea Conditions during the Flight Check

Date	Flight Check			Wind		Wave			
	Object			Direc-tion	V	Wave		Swell	
	LLZ	GS	PAPI			H _{1/3}	T _{1/3}	H _{1/3}	T _{1/3}
Sept. 30	A								
	P	○	○	SSE	2.3	47	3.2		
Oct. 1	A			NNE	7.7	64	3.1		
	P	○	○	N	8.8	52	3.1	1.6	15
	A								
5	P		○	N	6.4	35	2.8	1.5	12
	A		○	NNE	4.3	28	2.8	1.7	11
6	P		○	N	2.1	35	2.8		
	A		○	NNW	5.8	24	3.0	2.5	17
8	P		○	N	5.7	37	3.0		
	A	○		NNE	2.6	23	2.8		
12	P	○	○	NE	3.2	21	2.9	2.3	19
	A								
14	P		○	N	2.3	32	2.8		
	A		○	NNE	10.4	38	2.9		
18	P			NE	8.2	73	3.6		

H_{1/3} : Effective Height (cm), T_{1/3} : Effective Period (sec),
V: Wind Velocity (m/sec) (10-min. Ave.), A: A.M., P: P.M.

Both wave and swell affect the motion of Mega-Float and they are both observed in the site, therefore, the analysis on the swell is now in process.

3.2.2 The Motion of the MF Airport Model

1) Rotation of the Ground, where PAPI installed i. The Result of Optical Motion Measuring System

In this system, three fix points, locate in different distances and directions, are observed through telescope, then the motions of three fix points are analyzed. Then the rotations around longitudinal and transverse axis are calculated. Fig. 6 illustrates the location of observation and fix points. As fix points, three dolphins D3, D4 and D5 are selected. Distances from observation point to dolphins are around 311m (D3), 86m (D4) and 190m (D5). Fig. 7 shows an example of the relative motion of each dolphins observed and rotations around longitudinal and transverse axis calculated. The rotation of the ground, where PAPI installed, is tabulated in Table 2. Quite small about 0.02degree rotation is observed on October 1, when the flight check on PAPI was conducted and the wave height of 0.52m was observed.

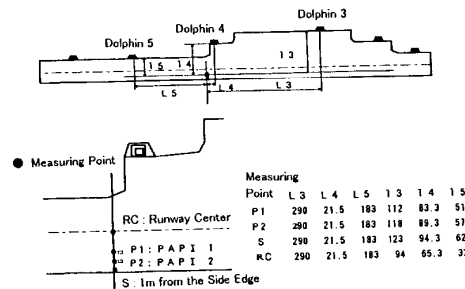


Fig. 6 Locations of Observation and Fix Points used for Optical Motion Measurement

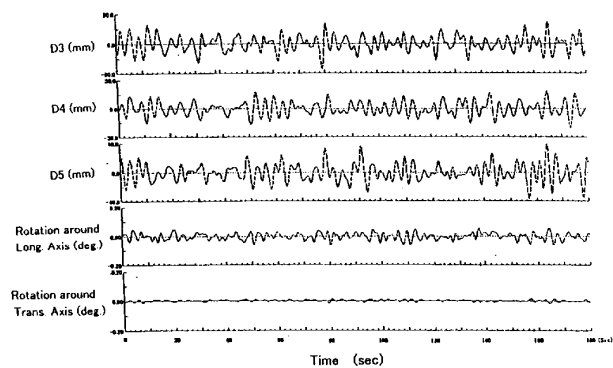


Fig. 7 Typical Data obtained by the Optical Measuring System

Table 2 Rotation Angles during the Flight Check, measured by the Optical System

Observation Point		Observation Date		Rotation Angle * (deg.)
PAPI	1	Oct. 1	14:47:01	0.020
			14:52:42	0.022
			15:00:47	0.023
	2	Oct. 5	13:18:48	0.025
			13:26:50	0.023
			13:34:00	0.022
Runway Center		Oct. 1	15:20:03	0.023
M.F. Side Edge		Oct. 1	15:36:06	0.027

* : around Transverse Axis

ii. The Result of Inclinator

The rotation was also measured with inclinometer, which calculates the inclination from the longitudinal ingredient of gravity. From the inclinometer set up near PAPI, indicates around 0.015degree rotation, which is the same level as measured with the optical system.

iii. The Result from Accelerometers

Vertical acceleration was measured with accelerometers, which are located in various locations of the MF airport model (see Fig. 4). Based upon these vertical acceleration data, the motion of the model is being calculated and analyzed.

2) The Motion of GS Reflection Area

Glide path, which guides the approaching airplane for landing, is formed with a synthesis of direct and reflected electric waves from GS antenna. Electric waves from GS antenna are reflected mainly by the GS reflection area (see Fig. 2), thus the motion of GS reflection area has a great role on the formation of Glide path. Therefore, the motion (deformation) of GS reflection area during the flight check was measured and analyzed. According to the calculation based upon the sea condition, i.e. wave height and wave period, around 150m long deformation wave appears in the GS reflection area. Since the height of this deformation wave (or vertical displacement) is small such as less than 20mm, inclination of the area is calculated to be around 0.01degree.

3.2.3 Tentative Flight Check Report

The final report on the flight check is in preparation. The followings are foreseen.

1) PAPI

Through 2-day flight check, good inspection results are obtained. Effect of the motion caused by the wave was not observed. Good accordance between PAPI and ILS/GS, both of which provide the same approach path of 3 degree, were confirmed with eye inspection.

2) ILS

i. LLZ

Within 18NM (33.3km) from the MF airport model, good results are obtained. Effect of the motion of the model was not observed.

ii. GS

Under the sea conditions during the flight check, effect of the motion of the model was not observed obviously. GS on the MF airport model enough satisfied the specification for acceptance.

Though the effective wave height during the flight check reached 0.64m, which covers over 85% reappearance probability in the site, the motion of MF airport model is too small to be observed by flight check. And flight checks under more severe wave conditions, i.e. under larger motion of the model, seems difficult. Accordingly, a flight check under the condition with artificially deformed GS reflection area is now in plan. Artificial deformation of GS reflection area will be prepared with the change of ballast water levels of the model. Through this flight check, glide slope data under severely deformed GS reflection area will be obtained and be utilized for the verification of glide slope analysis

program.

4.4 Experiments in 2000

As indicated in Fig. 2, airplane-landing practice is scheduled in this year. Considering the runway length of 900m, small and medium size 2 reciprocating-engine airplanes such as Britten-Norman BN-2, Beech B-99 and Dornier Do228 are nominated. Flight operation trial under FANS/GBAS with Beech B-99 is also scheduled by Electronic Navigation Research Institute (ENRI). In parallel to the landing practice, characteristic such as noise, vibration, magnetic field etc. will be measured to confirm the reliabilities of analysis programs so far established.

4. Conclusion

First flight check on PAPI and ILS, which were installed on the Mega-Float airport model at Yokosuka bay, was conducted and indicates both PAPI and ILS (LLZ/GS) are functioning well. Since the motion of the MF airport model is small, effect of wave on the function of PAPI and ILS was not observed. Additional flight check to observe the effect of deformation of the model on glide path is in preparation.

Airplane-landing practices under VFR and FANS/GBAS are scheduled this summer.

5. References

- 1) T. KIKUTAKE, 'A Mega-Float Airport, the State of the Art', OMAE '98
- 2) 1998 Annual Report, Technological Research Association of Mega-Float